

Table 8. Hells Canyon bighorn sheep habitat model

HABITAT COMPONENT	Criteria	Source
ESCAPE TERRAIN		
Slope	$31^{\circ} \leq \text{slope} \leq 85^{\circ}$	Gudorf and Sweanor 1996, Smith et al.
Buffer	300m or land areas $\leq 1000\text{m}$ wide bounded on ≥ 2 sides by escape terrain (500m)	Smith et al. 1991, Gudorf and Sweanor 1996
Minimum area	1.6 ha	Gudorf and Sweanor 1996
HORIZONTAL VISIBILITY	grassland, rock, open shrub or forest cover $< 40\%$, from satellite imagery	Schirokauer 1996
WATER SOURCES	≤ 3.2 km	Smith et al. 1991, Gudorf and Sweanor 1996
SUMMER RANGE	suitable habitat within 300m of escape terrain	Smith et al. 1991, Gudorf and Sweanor 1996, Schirokauer 1996
WINTER RANGE	suitable habitat all aspects below 4,800', aspect $135^{\circ} -$ 225° above 4,800'	Smith et al. 1991, Gudorf and Sweanor 1996, Coggins pers. comm.
LAMBING RANGE	escape terrain $45^{\circ} - 315^{\circ} \leq$ 1 km from water ≥ 2 contiguous ha	Gudorf and Sweanor 1996

Table 9. Extent and ownership of potential bighorn sheep habitat in the Hells Canyon project area.

Bighorn habitat type	Area ha (ac)	Ownership % (ha)				
		USFS	BLM	State	Private	Other ¹
Lambing	105,451 (260,570)	64% (67,144)	9% (9,643)	4% (4,351)	22% (23,262)	1% (762)
Winter	427,189 (1,055,588)	41% (176,416)	10% (44,372)	7% (28,690)	40% (172,799)	2% (4,912)
Total	541,221 (1,337,356)	53% (285,737)	8% (44,921)	6% (29,751)	32% (175,845)	1% (4,967)

¹ Other federal, county, tribal, and Nature Conservancy.

Table 10. Habitat improvements, Hells Canyon project area through 1997.

	Location	No. of sites or area
Water developments	Chalk - Mountain Sheep Creek	2
	Lower Imnaha	9
	Jim Creek/Downey Gulch	10
	Cherry Creek	6
	Lostine	1
	Wenaha	3
	Joseph Creek	4 (planned)
	Redbird-Captain John Creek	8
	Cottonwood Creek	1
<i>Total water developments</i>		44
Mineral/salt licks	Hass Ridge	2 salt
	Imnaha Gorge	3 salt/ivermectin
	Chalk Creek - Knight Creek	2 salt/ivermectin
	Chalk Creek	1 natural lick
	Downey Creek	2 salt/ivermectin
	Wenaha	2 salt/ivermectin
	Table Mountain	2 salt/ivermectin
	Hells Canyon Creek	1 salt
	Stud Creek	1 natural lick
	Lostine	1 salt/ivermectin
	Bear - Hurricane Creek	2 salt
<i>Total mineral/salt licks</i>		19
Planting/irrigation	Eden Bench alfalfa field	30 acres
	Wenaha Sheep Trap alfalfa field	30 acres

Table 10, cont'd. Habitat improvements, Hells Canyon project area through 1997.

Location		No. of sites or area
Wenaha Sargent alfalfa field		15 acres
Captain Lewis irrigation/pasture		20 acres (planned)
<i>Total planting area</i>		95
Prescribed burns	Lostine - 1992	200 acres
	Cactus Mountain - 1992	300 acres
	Haas Ridge - 1993	100 acres
	Dough Creek - 1995	30 acres
<i>Total prescribed fire area</i>		630 acres
Wildfires	Heavens Gate - 1996	425 acres
	Dam - 1996	4,800 acres
	Sheep Creek - 1996	11,000 acres
	Salt Creek - 1996	52,600 acres
	Captain John - 1996	400 acres
<i>Total wildfire area</i>		69,225 acres

Table 11. Potential bighorn sheep release sites in the Hells Canyon project area.

Location	State	Status
Bear Ridge	Oregon	Reintroduction
Cache Creek	Oregon	Reintroduction
Deep Creek	Oregon	Reintroduction
Tryon Creek	Oregon	Reintroduction
Pumpkin Creek	Oregon	Reintroduction
Sheep Divide	Oregon	Reintroduction
Devils Gulch	Oregon	Reintroduction
Cornucopia	Oregon	Reintroduction
Sand Creek	Oregon	Reintroduction
Spring Creek	Oregon	Reintroduction
Mud Creek	Oregon	Reintroduction
Grande Ronde	Oregon	Reintroduction
Table Mountain	Oregon	Supplement
Deadhorse Ridge	Oregon	Supplement
Minam	Oregon	Supplement
Battle Creek	Oregon	Supplement
Hells Canyon Dam	Oregon	Supplement
Deer Creek	Idaho	Reintroduction
Wolf Creek	Idaho	Reintroduction
Big Canyon Creek	Idaho	Reintroduction
Sheep Creek	Idaho	Reintroduction
Granite Creek	Idaho	Supplement
Bernard Creek	Idaho	Supplement
Frenchy Creek	Idaho	Supplement

Table 11, cont'd. Potential bighorn sheep release sites in the Hells Canyon project area.

Location	State	Status
Captain John Creek	Idaho	Supplement
Birch Creek	Idaho	Supplement
Asotin Creek	Washington	Supplement
Wenaha	Washington	Supplement
Joseph Creek	Washington	Supplement

¹ Reintroduction indicates site is currently unoccupied. Supplement indicates bighorn sheep are present.

Table 12. Release site ranking: distance and barriers to domestic sheep allotments.

Location	State	Distance to closest domestic sheep allotment (km)	20 points for each barrier to domestic sheep ^a	Score
Captain John Creek	Idaho	101.2	20	121.2
Cache Creek	Oregon	84.3	20	104.3
Deer Creek	Idaho	83.3	20	103.3
Bear Ridge	Oregon	78.5	20	98.5
Birch Creek	Idaho	75.2	20	95.2
Deadhorse Ridge	Oregon	71.8	20	91.8
Cave Gulch	Idaho	83.4	0	83.4
Frenchy Creek	Idaho	71.1	0	71.1
Deep Creek	Oregon	57.5	20	77.5
Tryon Creek	Oregon	46.1	20	66.1
Minam	Oregon	45.1	20	65.1
Devils Gulch	Oregon	24.6	40	64.6
Sheep Divide	Oregon	23.7	40	63.7
Pumpkin Creek	Oregon	38.6	20	58.6
Table Mountain	Oregon	16.5	40	56.5
Wolf Creek	Idaho	56.1	0	56.1
Asotin Creek	Washington	55.2	0	55.2
Wenaha	Washington	29.9	20	49.9
Joseph Creek	Washington	46.2	0	46.2
Big Canyon Creek	Idaho	45.6	0	45.6
Grande Ronde	Oregon	23.5	20	43.5

^a Barriers are major rivers (Snake, Salmon, and Imnaha) and extensive areas of unsuitable habitat.

Table 12, cont'd. Release site ranking: distance and barriers to domestic sheep allotments.

Location	State	Distance to closest domestic sheep allotment (km)	20 points for each barrier to domestic sheep ^a	Score
Sheep Mountain	Oregon	23.3	20	43.3
Sand Creek	Oregon	22.5	20	42.5
Kirkwood Creek	Idaho	32.5	0	32.5
Battle Creek	Oregon	8.0	20	28
Sheep Creek	Idaho	22.6	0	22.6
Hells Canyon Dam	Oregon	0.6	20	20.6
Spring Creek	Oregon	0.6	20	20.6
Bernard Creek	Idaho	16.7	0	16.7
Mud Creek	Oregon	13.0	0	13
Granite Creek	Idaho	12.0	0	12
Granite Cliffs	Oregon	7.7	0	7.7
Cornucopia	Oregon	2.4	0	2.4

^a Barriers are major rivers (Snake, Salmon, and Imnaha) and extensive areas of unsuitable habitat.

Table 13. Release site ranking: distance and barriers to private land.

Location	State	Distance to private land (km)	20 points for each barrier ^a to private land	Score
Bernard Creek	Idaho	35.4	0	35.4
Sand Creek	Oregon	11.9	20	31.9
Granite Creek	Idaho	31.5	0	31.5
Battle Creek	Oregon	7.8	20	27.8
Sheep Creek	Idaho	27.3	0	27.3
Hells Canyon Dam	Oregon	18.6	0	18.6
Kirkwood Creek	Idaho	17.4	0	17.4
Tryon Creek	Oregon	14.4	0	14.4
Granite Cliffs	Oregon	12.6	0	12.6
Birch Creek	Idaho	5.4	0	5.4
Spring Creek	Oregon	4.6	0	4.6
Big Canyon Creek	Idaho	4.1	0	4.1
Deep Creek	Oregon	2.0	0	2.0
Pumpkin Creek	Oregon	1.9	0	1.9
Cache Creek	Oregon	1.4	0	1.4
Frenchy Creek	Idaho	1.4	0	1.4
Wenaha	Washington	1.0	0	1.0
Sheep Divide	Oregon	1.0	0	1.0
Minam	Oregon	0.8	0	0.8
Deadhorse Ridge	Oregon	0.7	0	0.7
Bear Ridge	Oregon	0.6	0	0.6

^a Barriers are major rivers (Snake, Salmon, and Imnaha) and extensive areas of unsuitable habitat.

Table 13, cont'd. Release site ranking: distance and barriers to private land.

Location	State	Distance to private land (km)	20 points for each barrier ^a to private land	Score
Asotin Creek	Washington	0.6	0	0.6
Mud Creek	Oregon	0.3	0	0.3
Grande Ronde	Oregon	0.3	0	0.3
Captain John Creek	Idaho	0.2	0	0.2
Deer Creek	Idaho	0.1	0	0.1
Devils Gulch	Oregon	0.1	0	0.1
Cave Gulch	Idaho	0.0	0	0.0
Sheep Mountain	Oregon	0.0	0	0.0
Cornucopia	Oregon	0.0	0	0.0
Table Mountain	Oregon	0.0	0	0.0
Wolf Creek	Idaho	0	0	0.0
Joseph Creek	Washington	0	0	0.0

^a Barriers are major rivers (Snake, Salmon, and Imnaha) and extensive areas of unsuitable habitat.

Table 14. Release site ranking: distance and barriers to 1995-96 die-off.

Location	State	Distance to 1995-96 die-off (km)	20 points for barriers ^a to die-off	Score
Sheep Mountain	Oregon	98.4	20	118.4
Granite Cliffs	Oregon	87.6	20	107.6
Spring Creek	Oregon	69	20	89
Cornucopia	Oregon	87.6	0	87.6
Hells Canyon Dam	Oregon	55.5	20	75.5
Battle Creek	Oregon	47.6	20	67.6
Granite Creek	Idaho	44.2	20	64.2
Minam	Oregon	39.3	20	59.3
Bernard Creek	Idaho	39.1	20	59.1
Sheep Creek	Idaho	34.2	20	54.2
Sand Creek	Oregon	34.1	20	54.1
Kirkwood Creek	Idaho	28.4	20	48.4
Big Canyon Creek	Idaho	20.5	20	40.5
Devils Gulch	Oregon	34.4	0	34.4
Wolf Creek	Idaho	13.5	20	33.5
Sheep Divide	Oregon	33.0	0	33
Tryon Creek	Oregon	18.6	0	18.6
Asotin Creek	Washington	16.9	0	16.9
Deer Creek	Idaho	15.3	0	15.3
Pumpkin Creek	Oregon	13.8	0	13.8
Table Mountain	Oregon	13.5	0	13.5

^a Barriers are major rivers (Snake, Salmon, and Imnaha) and extensive areas of unsuitable habitat.

Table 14, cont'd. Release site ranking: distance and barriers to 1995-96 die-off.

Location	State	Distance to 1995-96 die- off (km)	20 points for barriers ^a to die-off	Score
Deep Creek	Oregon	7.4	0	7.4
Birch Creek	Idaho	6.6	0	6.6
Bear Ridge	Oregon	6.1	0	6.1
Mud Creek	Oregon	3.9	0	3.9
Cave Gulch	Idaho	2.7	0	2.7
Cache Creek	Oregon	1.6	0	1.6
Grande Ronde	Oregon	0	0	0
Deadhorse Ridge	Oregon	0	0	0
Frenchy Creek	Idaho	0	0	0
Captain John Creek	Idaho	0	0	0
Wenaha	Washington	0	0	0
Joseph Creek	Washington	0	0	0

^a Barriers are major rivers (Snake, Salmon, and Imnaha) and extensive areas of unsuitable habitat.

Table 15. Release site ranking: extent of lambing habitat.

Location	State	Potential lambing habitat (m ²) within 10 km radius	Percent ^a
Bernard Creek	Idaho	137,488,583	43.99%
Granite Creek	Idaho	81,809,249	26.17%
Battle Creek	Oregon	79,435,576	25.41%
Sheep Creek	Idaho	76,116,971	24.35%
Hells Canyon Dam	Oregon	64,626,641	20.68%
Kirkwood Creek	Idaho	54,259,032	17.36%
Sand Creek	Oregon	52,192,426	16.70%
Frenchy Creek	Idaho	52,000,724	16.64%
Granite Cliffs	Oregon	51,649,741	16.52%
Deadhorse Ridge	Oregon	49,925,869	15.97%
Pumpkin Creek	Oregon	45,977,423	14.71%
Bear Ridge	Oregon	45,863,198	14.67%
Cache Creek	Oregon	39,747,084	12.72%
Cave Gulch	Idaho	39,545,390	12.65%
Sheep Divide	Oregon	39,500,770	12.64%
Birch Creek	Idaho	38,003,652	12.16%
Big Canyon Creek	Idaho	36,602,245	11.71%
Joseph Creek	Washington	34,711,695	11.11%
Tryon Creek	Oregon	34,359,585	10.99%
Spring Creek	Oregon	32,654,204	10.45%
Deep Creek	Oregon	32,371,101	10.36%
Wolf Creek	Idaho	29,904,458	9.57%

^a Calculated as the percent of the area within 10 km of release site with habitat information available that was classified as lambing habitat.

Table 15, cont'd. Release site ranking: extent of lambing habitat.

Location	State	Potential lambing habitat (m ²) within 10 km radius	Percent ^a
Devils Gulch	Oregon	26,266,435	8.40%
Table Mountain	Oregon	23,199,723	7.42%
Sheep Mountain	Oregon	22,000,761	7.04%
Minam	Oregon	- ^b	5.56%
Captain John Creek	Idaho	16,155,907	5.17%
Cornucopia	Oregon	15,743,986	5.04%
Mud Creek	Oregon	- ^b	4.83%
Grande Ronde	Oregon	-	2.30%
Wenaha	Washington	-	1.71%
Asotin Creek	Washington	-	0.28%
Deer Creek	Idaho	-	-

^a Calculated as the percent of the area within 10 km of release site with habitat information available that was classified as lambing habitat.

^b Habitat information not available for entire 10 km radius around release site.

Table 16. Release site ranking: extent of wintering habitat.

Location	State	Potential wintering habitat (m ²) within 30 km radius	Percent ^a
Deadhorse Ridge	Oregon	1,413,485,327	50.25%
Deep Creek	Oregon	1,383,472,979	49.18%
Frenchy Creek	Idaho	1,376,137,068	48.92%
Wolf Creek	Idaho	- ^a	48.55%
Tryon Creek	Oregon	-	46.79%
Kirkwood Creek	Idaho	-	46.64%
Big Canyon Creek	Idaho	-	46.59%
Birch Creek	Idaho	1,307,109,169	46.47%
Bear Ridge	Oregon	1,256,813,658	44.68%
Cache Creek	Oregon	1,248,402,120	44.38%
Cave Gulch	Idaho	1,245,976,545	44.29%
Pumpkin Creek	Oregon	1,218,899,281	43.33%
Joseph Creek	Washington	1,176,851,035	41.84%
Sand Creek	Oregon	-	41.78%
Sheep Creek	Idaho	-	41.52%
Bernard Creek	Idaho	137,488,583	36.55%
Captain John Creek	Idaho	993,926,175	35.33%
Granite Creek	Idaho	921,494,562	32.76%
Sheep Divide	Oregon	899,358,854	31.97%
Grande Ronde	Oregon	-	30.47%
Battle Creek	Oregon	842,380,804	29.95%
Table Mountain	Oregon	-	29.89%

^a Habitat information not available for entire 30 km radius.

^b Calculated as the percent of the area within 30 km of release site with habitat information available that was classified as wintering habitat.

Table 16, cont'd. Release site ranking: extent of wintering habitat.

Location	State	Potential wintering habitat (m ²) within 30 km radius	Percent ^a
Mud Creek	Oregon	-	26.39%
Wenaha	Washington	-	25.76%
Devils Gulch	Oregon	712,931,270	25.34%
Hells Canyon Dam	Oregon	664,947,444	23.64%
Spring Creek	Oregon	577,378,145	20.53%
Asotin Creek	Washington	-	20.42%
Sheep Mountain	Oregon	-	19.64%
Cornucopia	Oregon	-	12.10%
Granite Cliffs	Oregon	231,147,885	8.22%
Minam	Oregon	-	7.52%
Deer Creek	Idaho	-	-

^a Habitat information not available for entire 30 km radius.

^b Calculated as the percent of the area within 30 km of release site with habitat information available that was classified as wintering habitat.

Table 17. Release site ranking: distance to occupied habitat.

Location	State	Distance to nearest herd (km)
Devils Gulch	Oregon	21.3
Kirkwood Creek	Idaho	16.2
Spring Creek	Oregon	13.7
Cornucopia	Oregon	13.2
Minam	Oregon	12.5
Deer Creek	Idaho	12.5
Sheep Divide	Oregon	12.5
Granite Cliffs	Oregon	9.6
Big Canyon Creek	Idaho	7.6
Bear Ridge	Oregon	6.1
Tryon Creek	Oregon	5.8
Sheep Creek	Idaho	5.8
Wolf Creek	Idaho	5.3
Sand Creek	Oregon	4.9
Mud Creek	Oregon	3.9
Pumpkin Creek	Oregon	3
Cave Gulch	Idaho	2.3
Cache Creek	Oregon	1.6
Birch Creek	Idaho	1
Deadhorse Ridge	Oregon	0
Deep Creek	Oregon	0
Frenchy Creek	Idaho	0
Joseph Creek	Washington	0
Bernard Creek	Idaho	0

Table 17, cont'd. Release site ranking: distance to occupied habitat.

Location	State	Distance to nearest herd (km)
Captain John Creek	Idaho	0
Granite Creek	Idaho	0
Grande Ronde	Oregon	0
Battle Creek	Oregon	0
Table Mountain	Oregon	0
Wenaha	Washington	0
Hells Canyon Dam	Oregon	0
Asotin Creek	Washington	0
Sheep Mountain	Oregon	0

Table 18. Overall ranking of highest ranked release sites ^a, 1997.

Sites near the most lambing and winter range	Sites with least risk	Overall site ranking	Comments
Deadhorse Ridge, OR	Minam, OR	Tryon, OR	
Frenchy Creek, ID	Deer Creek, ID	Birch Creek, ID	Supplement
Kirkwood Creek, ID	Devil's Gulch, OR	Deep Creek, OR	
Bernard Creek, ID	Tryon, OR	Pumpkin Creek, OR	Near private land (1.9 km)
Sheep Creek, ID	Birch Creek, ID	Big Canyon Creek, ID	Near private land (4.1 km)
Granite Creek, ID	Sheep Divide, OR	Deer Creek, ID	Habitat information not available, on private land
Sand Creek, OR	Deep Creek, OR	Asotin Creek, WA	Habitat information incomplete, near private land (0.6 km), supplement
Pumpkin Creek, OR	Big Canyon Creek, ID		
Cache Creek, OR	Pumpkin Creek, OR		
Deep Creek, OR	Asotin Creek, WA		
Tryon Creek, OR			
Big Canyon Creek, ID			
Birch Creek, ID			

^a Release sites scoring in the top 10 (including ties) for habitat quantity, where available, and bottom 10 for risk.

Figure 1. Hells Canyon initiative project area and bighorn sheep herds.



▨ Bighorn Sheep Herd Areas

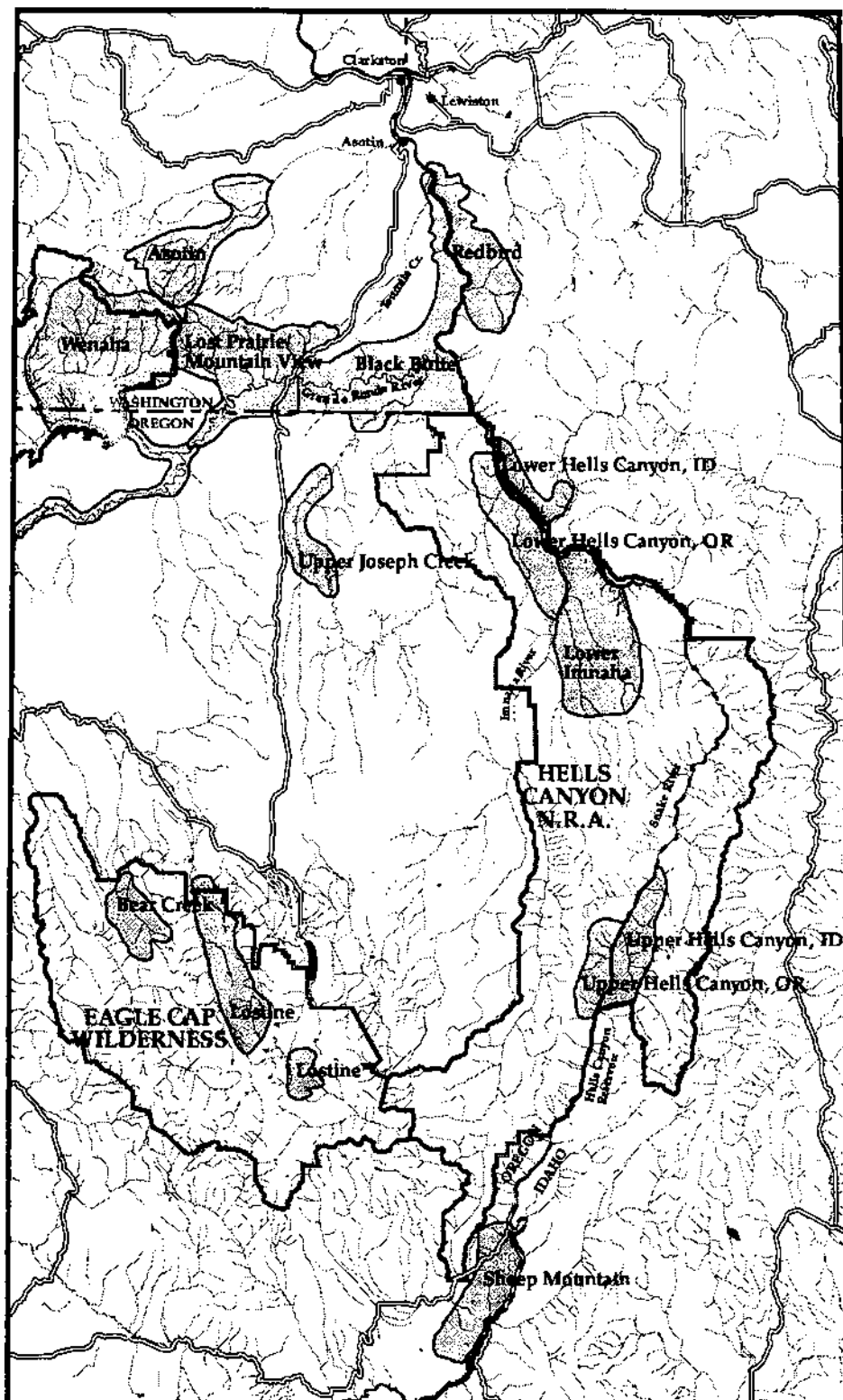
— State Boundaries

— Primary and Secondary Roads

— Perennial Streams and Lakes



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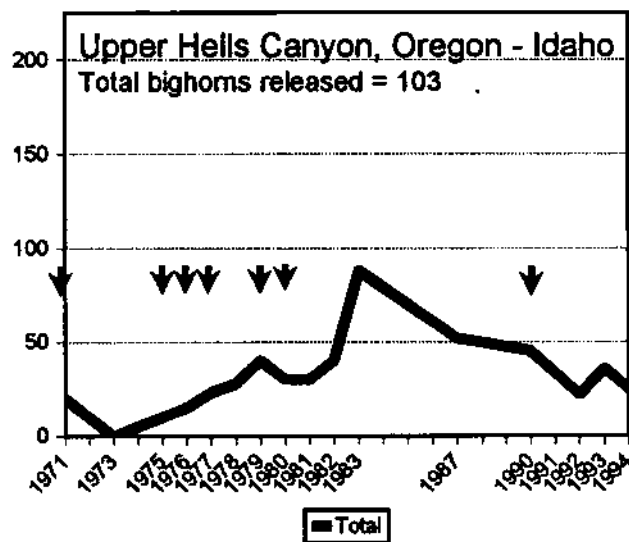
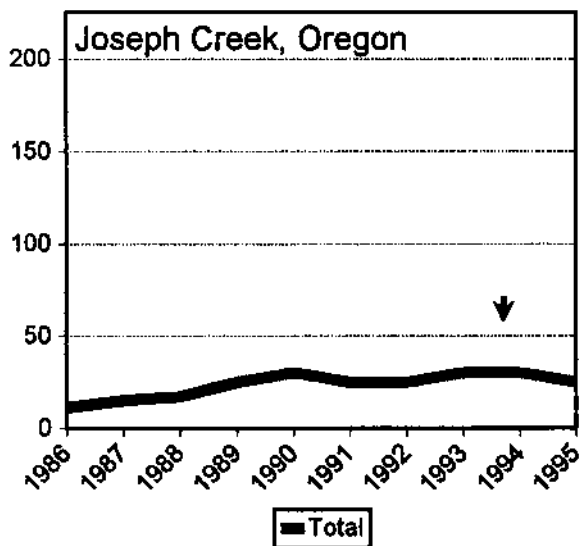
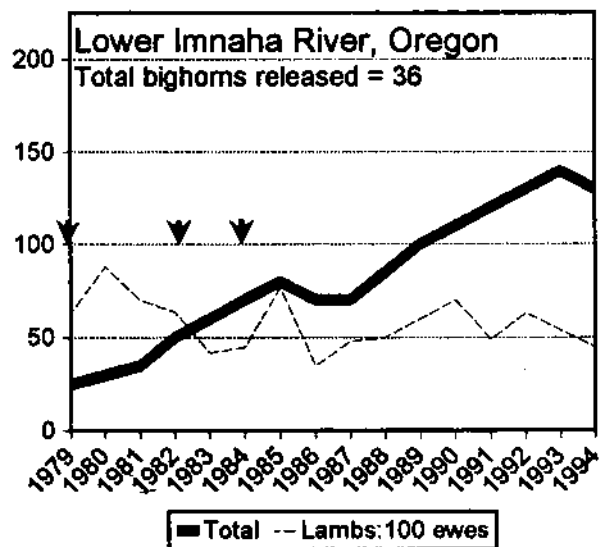
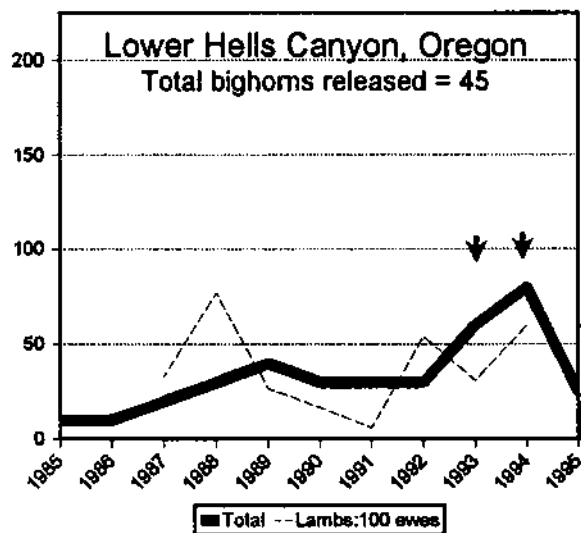
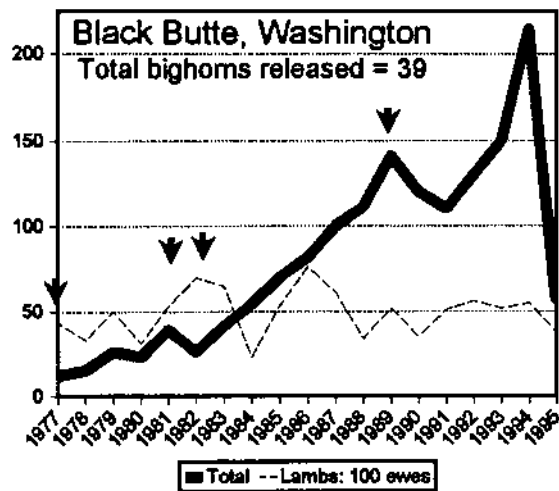
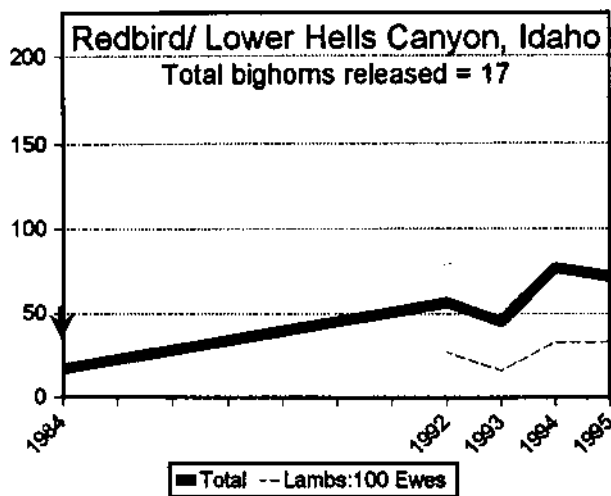


Figure 2. Size and lamb:ewe ratios of bighorn sheep herds in Hells Canyon 1971 - 1995.
↓ =date of release(s).

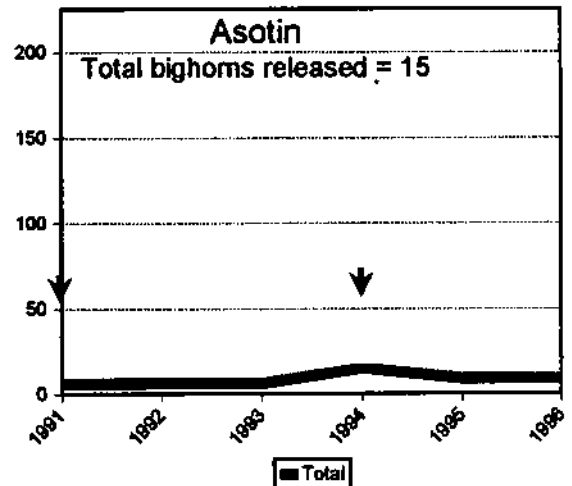
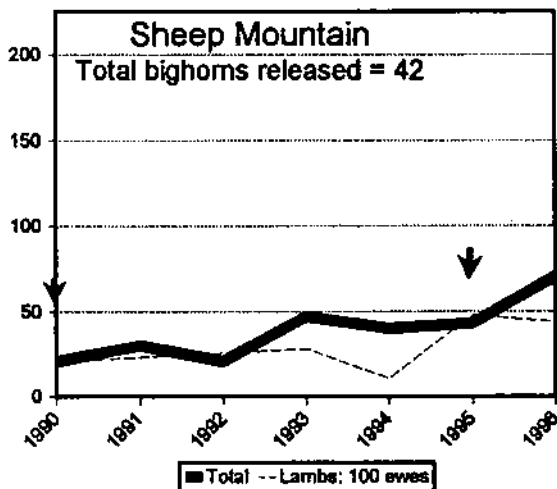
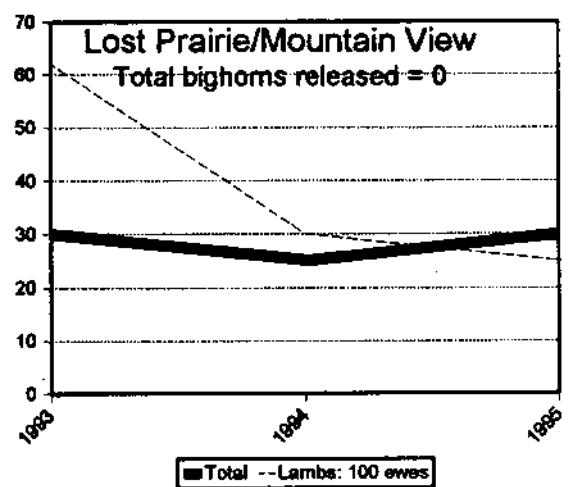
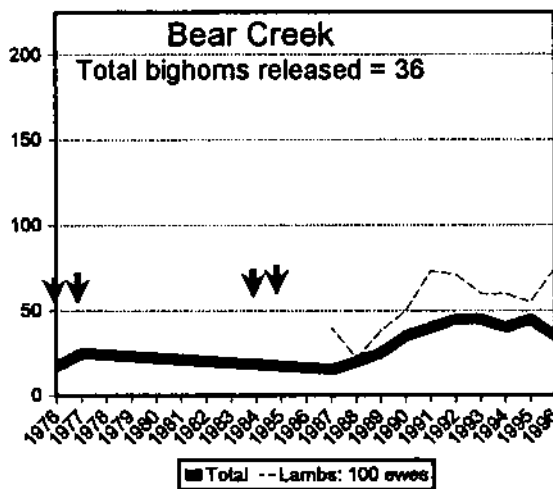
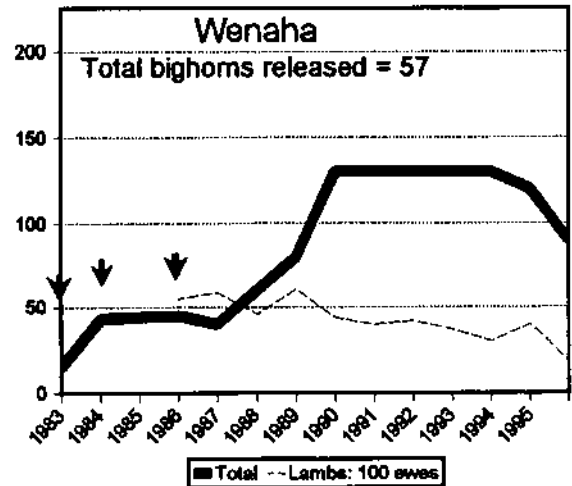
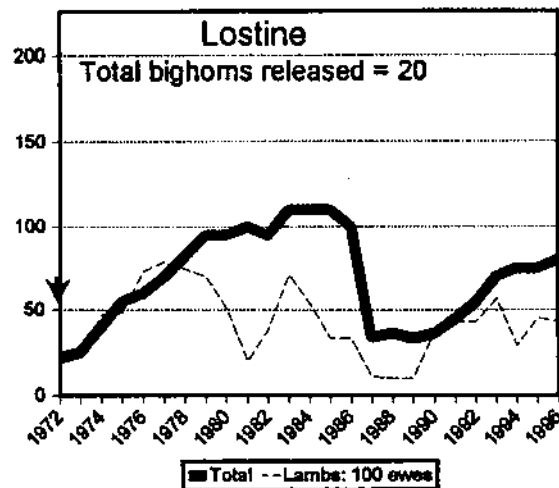


Figure 2, cont'd. Size and lamb:ewe ratios of bighorn sheep herds in Hells Canyon 1971 - 1995.
↓ = date of release(s).

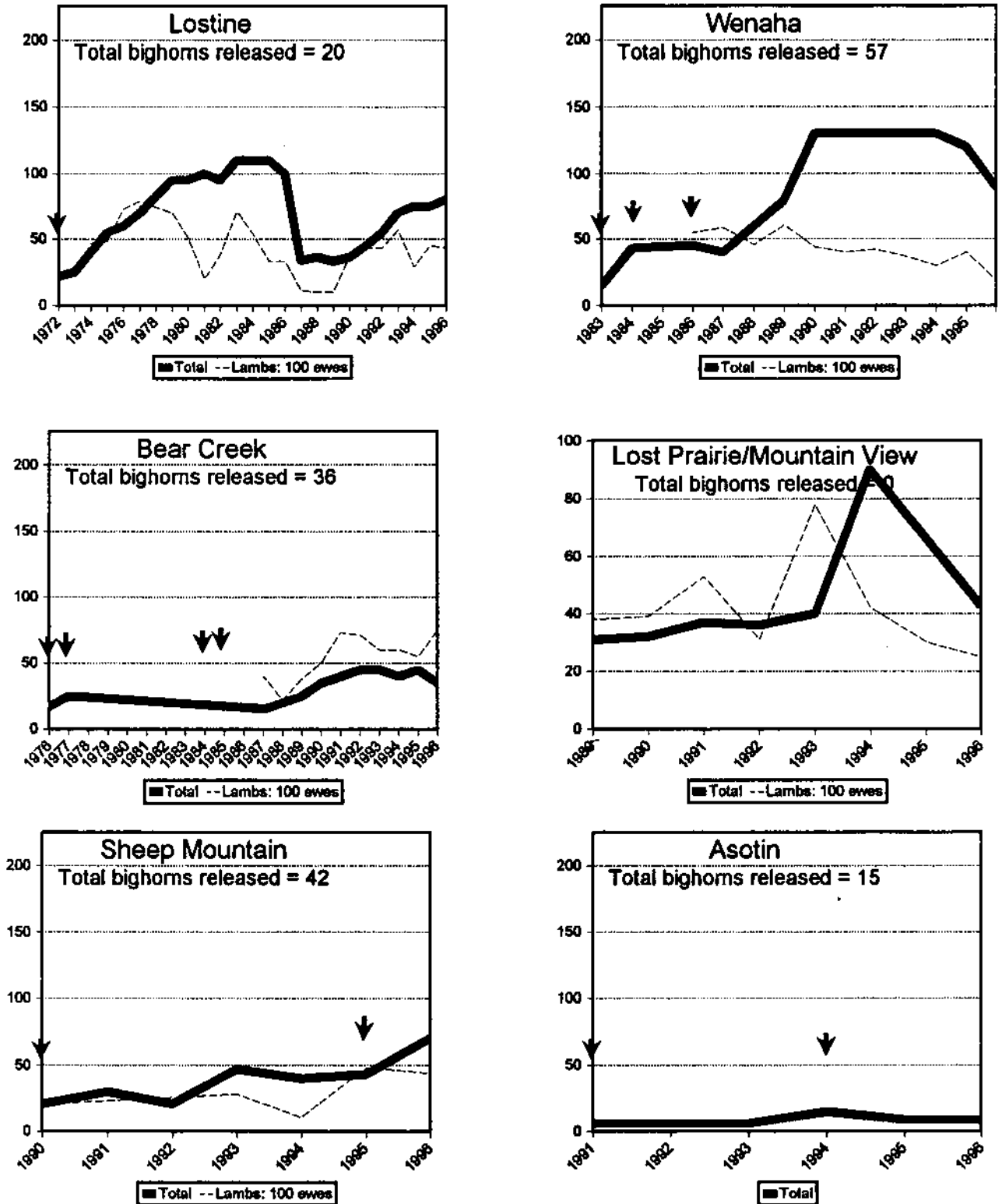
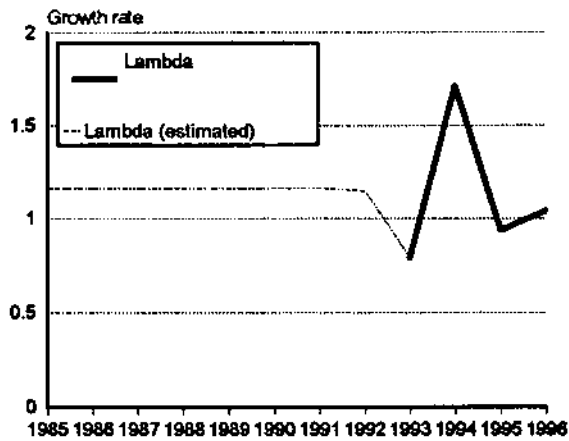
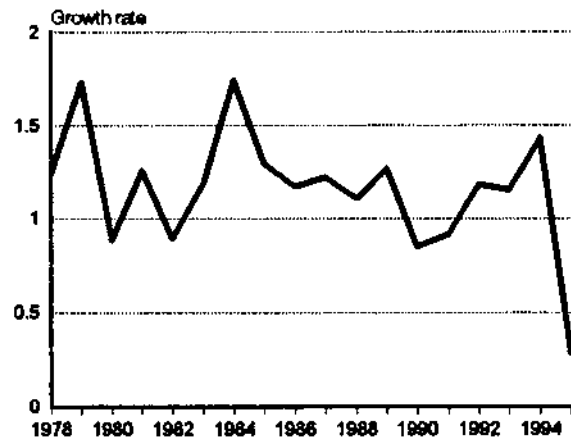


Figure 2, cont'd. Size and lamb:ewe ratios of bighorn sheep herds in Hells Canyon 1971 - 1995.
 ↓ =date of release(s).

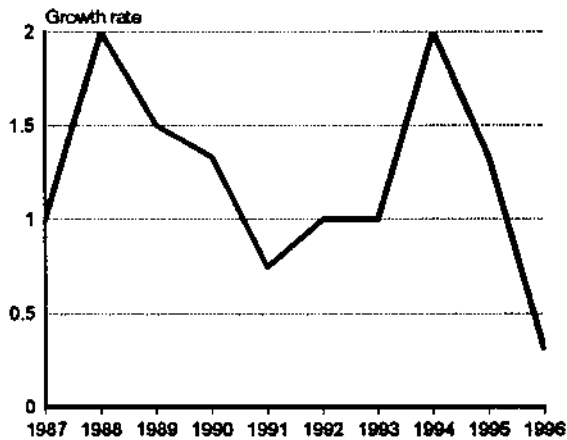
Redbird/Lower Hells Canyon, Idaho



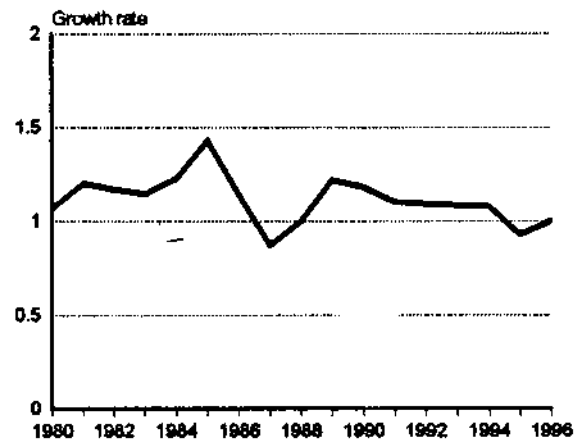
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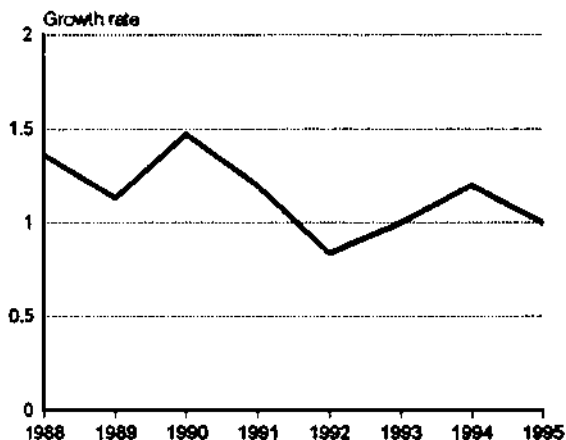
Lower Hells Canyon, Oregon



Innaha



Joseph Creek, Oregon



Upper Hells Canyon, Oregon

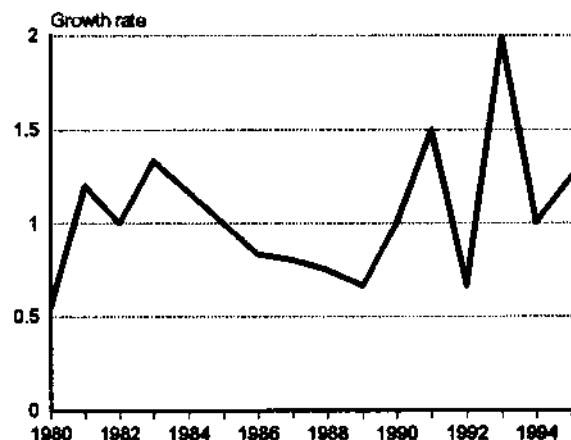
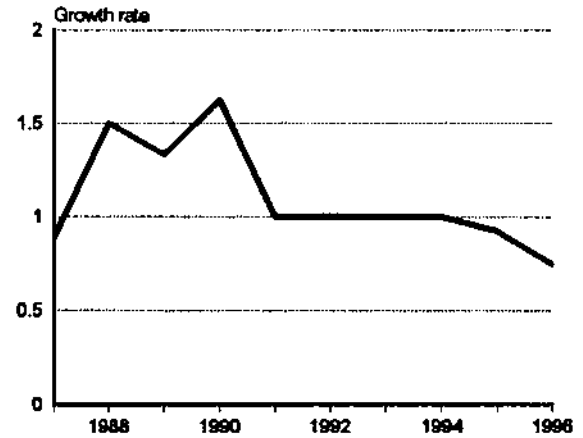


Figure 3. Growth rates of bighorn sheep herds in Hells Canyon.

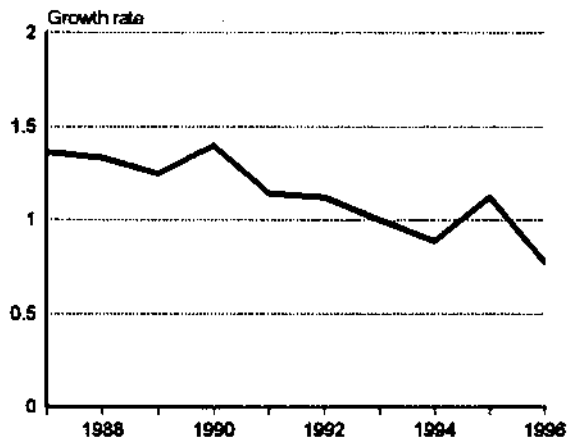
Lostine



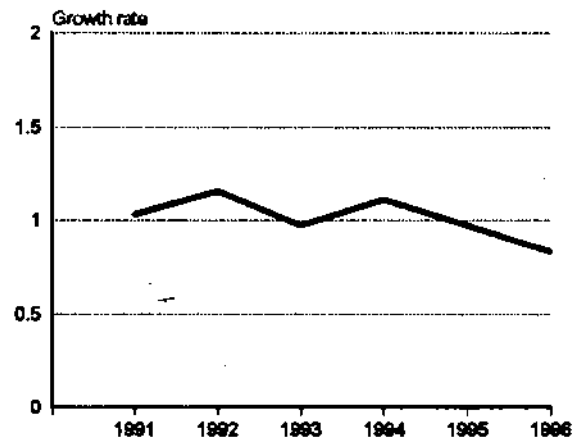
Wenaha



Bear Creek



Lost Prairie/Mountain View



Sheep Mountain

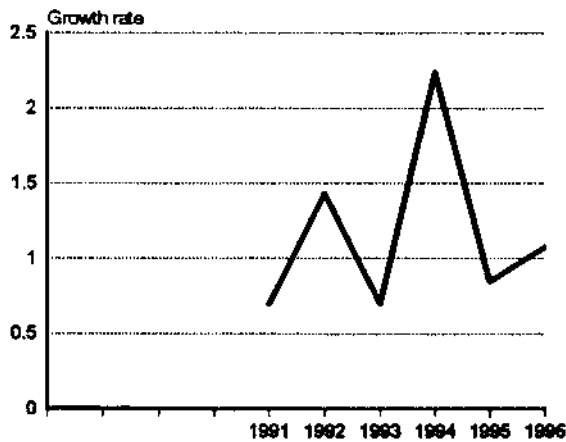
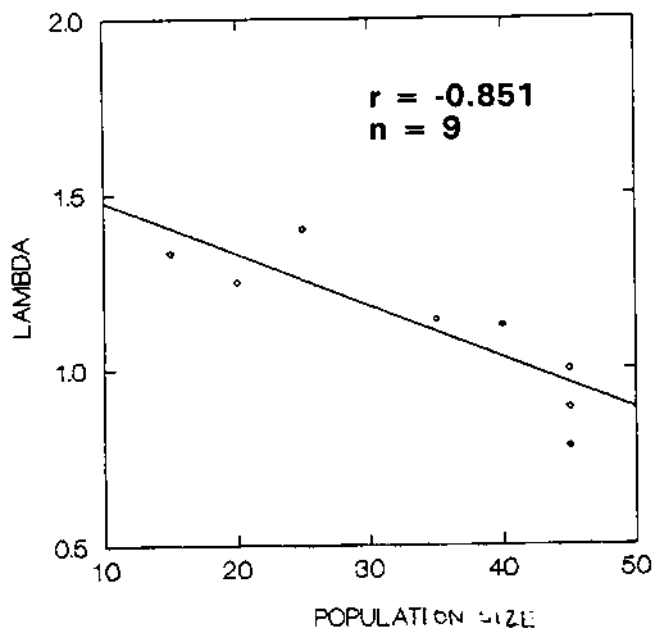


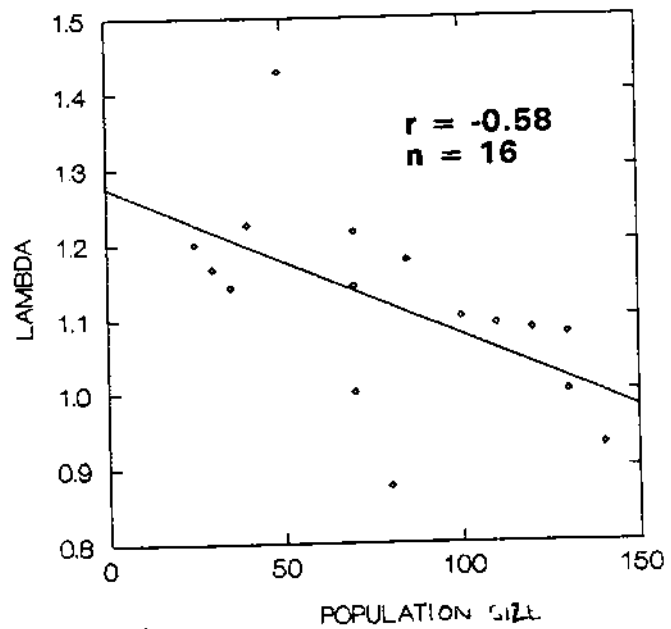
Figure 3, cont'd. Growth rates of bighorn sheep herds in Hells Canyon.

Figure 4. Relationship between growth rates and population size in Hells Canyon bighorn sheep.

BEAR CREEK 1988 - 1996



IMNAHA 1980 - 1996



BLACK BUTTE 1977-1994

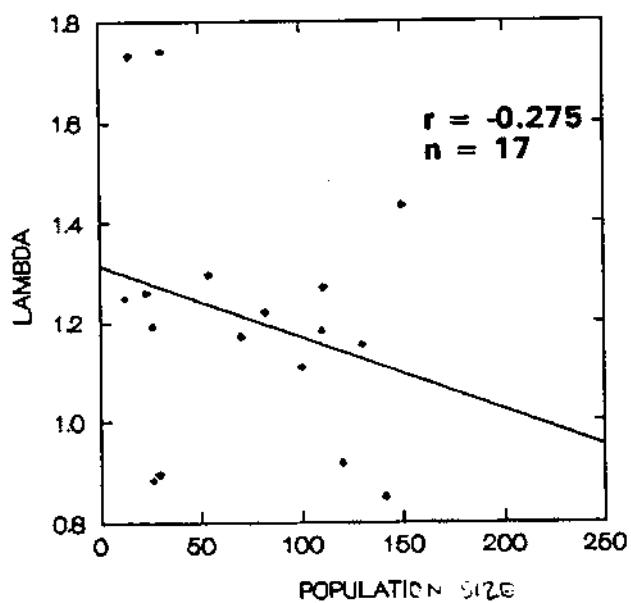
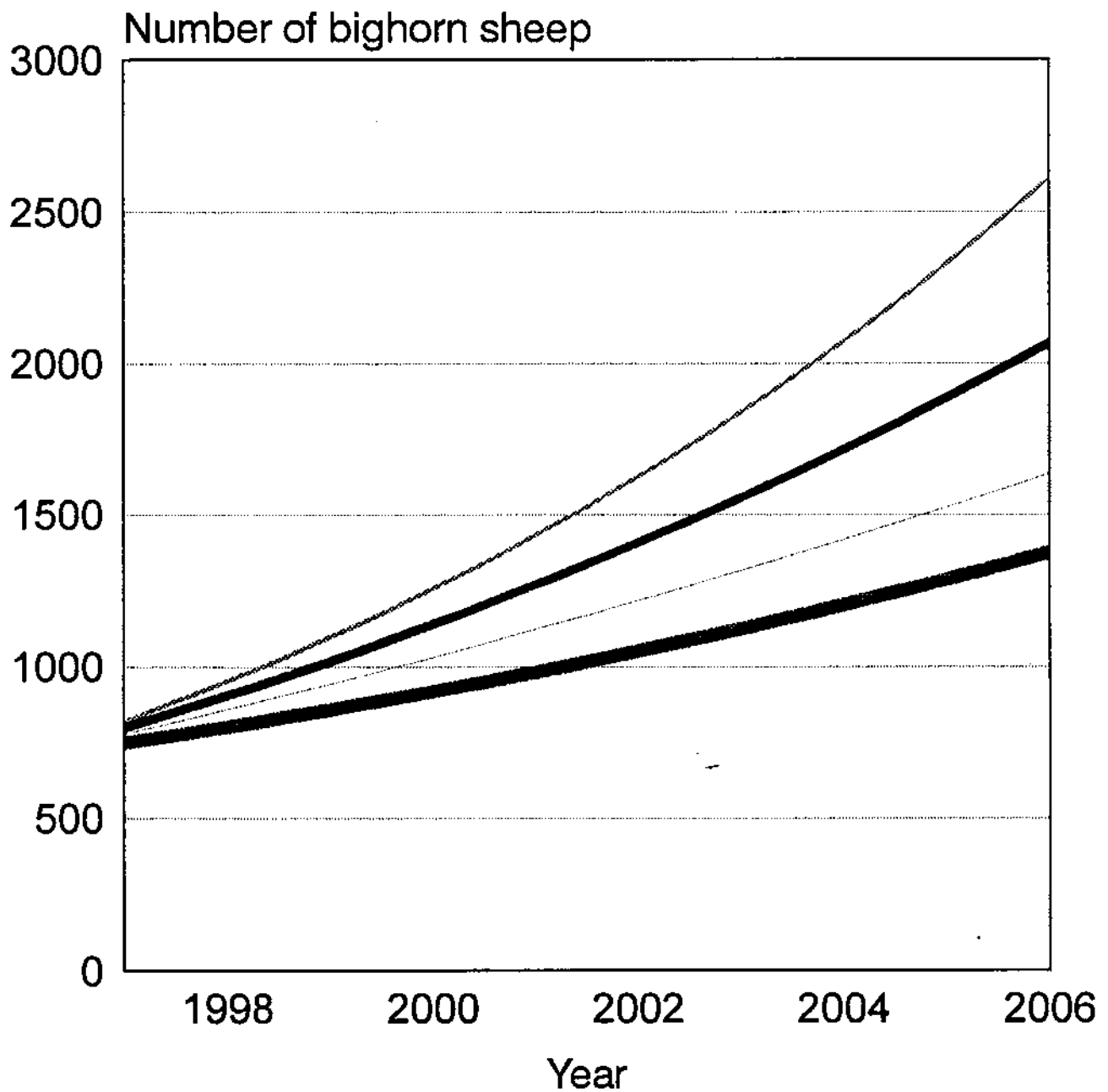
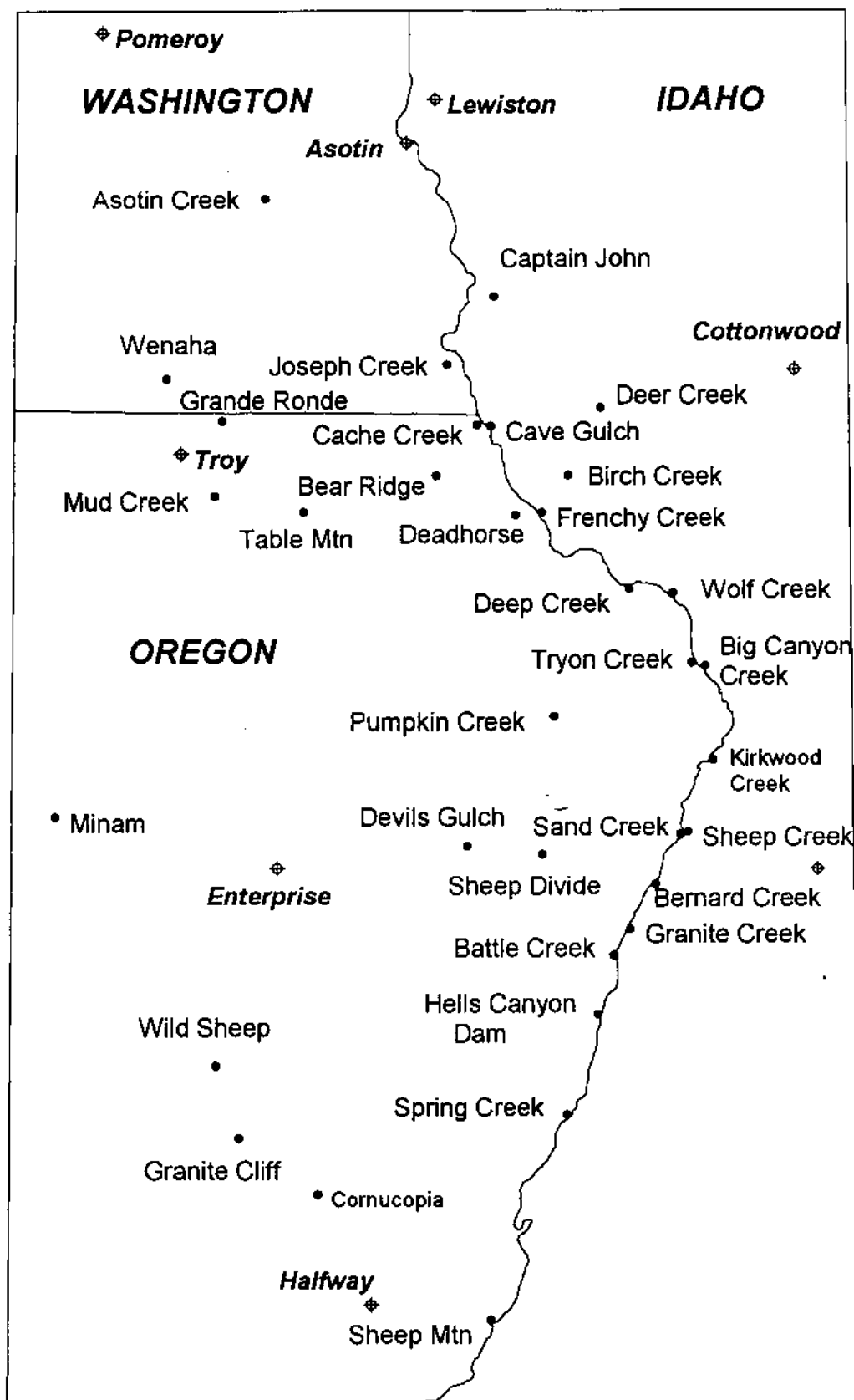


Figure 5. Projected bighorn sheep population trend in the Hells Canyon project area at various population growth rates and including annual releases of 50 bighorn sheep.



- growth 7%
- growth 7% + annual release of 50 bighorns
- growth 10% + annual release of 50 bighorns
- growth 4% + annual release of 50 bighorns

Figure 6. Potential bighorn sheep release sites, Hells Canyon project area.





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